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OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

How China's demand uncertainty moderates the responsiveness of operational performance to supply chain integration in automotive industry

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Abstract: This study aims at examining the dynamic response of the relationship between supply chain integration (SCI) and operational performance (OP) to demand uncertainty (DU). Based on a wide spectrum data sample with 357 participants in the China automotive supply chains, threshold regressions are used to examine the dynamic moderating effects. DU was found to moderate supplier integration (SI)–OP and customer integration (CI)–OP relationship. Internal integration (II)–OP relationship did not response to DU. The SI–OP relationship turned from negative to positive as DU increases, and CI–OP relationship responded to DU reversely compare to SI–OP relationship. Scholars now know the moderating effect of DU is not static and monotonic. Both of direction and magnitude of the correlations between SI, CI and OP change when DU changes. Managers of automotive supply chain recognize that their integrations' strength should be properly managed subject to the level of DU for propose of achieving optimal OP. This study extends the current literature by delivering a field study of China and introducing dynamic capability theory for the first time to examine a dynamic response model that represents the SCI–OP relationships with respect to the DU as a moderating factor.

Subjects: Customer Relationship Management (CRM); Enterprise Resource Management (ERP); Supply Chain Management

Keywords: supply chain integration; operational performance; demand uncertainty; china; automotive industry



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ABOUT THE AUTHORS

Yi Ding is a recently minted PhD and a postdoctoral researcher in the field of supply chain integration and performance. Over the last five years, Yi Ding has been working in the team of supply chain and logistics management led by Dawei Lu who is one of the authors to this paper. Linbang Fan, the third author of the paper, had also been a team member when he visited WMG University of Warwick as a visiting scholar from China about three years ago. Their key research activities are observing and investigating any newly developed trends and phenomenon in the field of supply chain integration, especially in delivering countries such as China. They provide fresh contributions to postgraduate teaching and to managerial practices in real-world industries through research-based consultancy.

PUBLIC INTEREST STATEMENT

Exposed to today's highly dynamic and competitive automotive industrial sector, people would like to see how the newly established concept of supply chain integration has anything to do with the automobile they are buying and the experiences they are having in using it. The research paper offers a simple idea that the success of the automotive giants they see on the advertisement are heavily reliant on the support from many other associated companies called suppliers. The ways of enjoyment with suppliers often determines the performance of the car and the performance of the company that makes it. More interestingly the effectiveness of such engagement may vary from circumstance to circumstance. Thus, for an equally competitive performance delivered as the outcome, what has been practiced in China could be very different from what has been practiced in the developed world.

1. Introduction

Researchers have long articulated the need for strategic integration between suppliers and customers in order to deliver the supply chain's optimal performance (Flynn, Huo, & Zhao, 2010; Huang, 2014). Supply chain integration (SCI) strategies that help to develop appropriate levels of collaboration and partnership have been regarded as indisputable factors for supply chain success. With many studies have been performed to examine the SCI-OP relationships in various research contexts, empirical findings tend to be inconsistent. Such inconsistency has been claimed on finding empirical negative (Swink & Song, 2007) and non-significant SCI-OP relationships (Devaraj, Krajewski, & Wei, 2007), which became a key reason for introducing follow-up and industry-specific studies (Jonsson, Andersson, Boon-itt, & Wong, 2011). By discovering the full spectrum of SCI-OP relationship distribution coupled with observation of a small number of inconsistent findings, the research focus shifted to examination of moderating and mediating effects of exogenous environmental factors by introducing contingency theory (Cao, Huo, Li, & Zhao, 2015; Wong, Boon-Itt, & Wong, 2011). These studies expanded our understanding of the scope required to establish strategic supply chain collaborations.

Yet despite the widespread acceptance of the environmental factors are critical for SCI management, the impact of demand uncertainty (DU) on integrational strategies from a dynamic perspective remains largely unexplored by researchers. To fill this research gap, we attempt to expand the scope of contingency argument of environments' moderation by introducing dynamic capability theory (DCT). We maintain that the dynamic capability is built-in in supply chain management mechanism, which endowed supply chains with ability of adjusting integration resource when face environmental changes. Moreover, we posit that the link between SCI and OP may responds dynamically to different levels of demand uncertainty. Building on the contingency theory and DCT, we seek to answer to the question of how demand uncertainty moderates the relationship between SCI and OP, particularly China automotive industry.

This study establishes an empirical model that includes SCI and OP with China automotive industry data and permits an unconstrained re-investigation of how the SCI-OP relationship dynamically responds to variation of demand uncertainty. The empirical results of this study may further contribute to our understanding of the nature of supply chain contextual factors.

The remainder of this study is organized as follows. First, we develop the theoretical basis of this study, including our arguments regarding the method in which DCT explains contingency-response relationships, and our research hypotheses. Subsequently, we present our research methodology and empirical results and discussions. Finally, the conclusions are presented with theoretical, managerial implications, limitations and future research.

2. Theoretical background and hypothesis development

SCI has been considered from an aggregated level (Cousins & Menguc, 2006) to a three sub-dimensions level (II, SI and CI) (Flynn et al., 2010; Huo, 2012), because the supply chain community perceived that different integration dimensions might have different effects on performance (Swink, Narasimhan, & Wang, 2007). It is also possible that the sensitivity of relationships between sub-dimensions and performance to contextual factors might differ from one another (Wong et al., 2011). Existing studies have provided empirical findings on how SCI dimensions affect performance based on static supply chain assumption. For example, Flynn et al. (2010)'s study observed positive effects from II and CI to OP with an insignificant effect from SI. Long term, such findings provide an argument to enhance II and CI since 'the more the better' and to ignore the non-contributor SI, which could be theoretically doomed before birth. Thus, contingency theory suggests that the strategic fitness between supply chain integrative behaviour and environmental changes would produce relatively optimal performance in the long term (Cao et al., 2015).

The resource-based view (RBV) suggests that all goods, information, capital and linkage between firms are considered as tangible and intangible resources (Wernerfelt, 1995). SCI management is an

approach to systematically synchronize and exploit supply chain resources to lower operational costs and improve performance (Prajogo & Olhager, 2012). Essentially, supply chain resources have varying levels of value and difficulty for competitors to imitate (Lavie, 2006). A supply chain can achieve continuous optimal performance by configuring these resources appropriately through integration management (Schoenherr & Swink, 2012). In addition, resources are valued and distributed consistently over time if one assumes that a supply chain operates in a static and unchanging environment (Veliyath, 1996). In contrast, when considering a dynamic environment context, the value of a specific supply chain resource might vary over time. The most influential changes in a dynamic environment are economic shocks, political uncertainty, unpredictable changes in demand and technology, as well as supply chain competitors' behaviour not always been identifiable (Eisenhardt & Martin, 2000).

Facing such environmental changes, the DCT is used to explain a long-term performance management (Helfat et al., 2009; Teece, Pisano, & Shuen, 1997). Helfat et al. (2009) defines dynamic capability as an organization's ability to purposefully create, extend and modify its resources. This definition has been interpreted by Hung, Lien, and McLean (2009), who indicate that supply chain value creation depends on the relative realized value by a supply chain manager. Thus, the marginal perceived amount of supply chain value can be achieved through effective resource synchronization and exploitation. Such a process is exactly the purpose of integration management. For the goal of maintaining a continuous optimal performance in an uncertain environment, the level of integration with either internal functions, suppliers or customers should be managed to associate with supply chain managers realized value subject to each dimension. This alignment process is also synchronized with environmental changes. Therefore, the method in which supply chain managers realize value of integration to maintain a dynamic capability for dealing with unpredictable environmental changes becomes the leveraging mechanism of integration management.

In the short term, static SCI management can indeed bring temporary advantage. Nevertheless, Hung et al. (2009) argue that dynamic capabilities will become an optimal choice for most supply chains since it has the ability to yield long-term competitive advantage. Such long-term competitive advantage is reflected by the capability of adjusting core competencies with changing resource valuation when environment is uncertain. Aller and Carlos (2010) indicated that the nature of dynamic processes is resource reallocation and reconfiguration. As such, for viability with extreme conditions, dynamic capability has usually been designed in organization specification (Makadok, 2001). However, scholars have long ignored DC's mechanism of leveraging organizations' decision-making since it is not necessary to include DC in an organization's periodic performance evaluation index. Finally, Zahra, Sapienza, and Davidsson (2006) find that an uncertain environment is not a necessary requirement for a DC to be successful, but DC can be used beneficially on several market environment uncertainties. In reality, today's globalization with supply chain partners distributed geographically with different types of regional uncertainties have been put forward as changing environments where DC is necessary in organizational management mechanism design (Helfat et al., 2009).

This discussion suggests that DC is part of an organization's top management and that it is more than a frequently utilized capability. DC provides routines to identify environmental threats and opportunities (Helfat et al., 2009); to reconfigure a supply chain's resource (Eisenhardt & Martin, 2000); to dynamically adjust SCI levels and to maintain a supply chain's competency for achieving long-term optimal performance. Thus, as an intangible resource, question can be raised regarding the realized valuation and utilized valuation of SCI remaining constant in the long term. Can DC leverage SCI's valuation change subject to environments? Should SCI monotonously generate superior performance? A plausible explanation for the existing inconsistency among the findings on SCI-OP relationship is that the contribution of an integration dimension to performance might be promoted or hindered by environmental conditions. However, based on DCT, a supply chain never operates in a stationary state, as the level of such promote/hinder effects depends on the level of environmental uncertainty. A supply chain is expected to initialize resource reconfigurations once a promote/hinder

effect has been realized. Thus, supply chain managerial discretion with respect to addressing environmental uncertainties is dynamically reflected by the supply chain resource reallocation and re-configuration. It is therefore, the relationship between SCI and OP that dynamically depends on different levels of environmental uncertainty.

2.1. Hypothesis: Relationship between SCI and OP under DU

Demand uncertainty refers to the level of difficulty in predicting future demand features (Bernstein & Federgruen, 2005). These features usually include demand preference change and demand volume change as a result and impact on a firm's operating procedures (Frohlich & Westbrook, 2002). The moderating effects of these transactional contingencies on the relationship between SCI and OP have been investigated from a static supply chain perspective in prior studies (Gimenez, van der Vaart, & Pieter van Donk, 2012; Jonsson et al., 2011; Wang, Chen, & Chen, 2012). However, the DCT suggests that the built-in dynamic capability in a supply chain should always re-evaluate, re-allocate and re-configure supply chain resources to compensate its losing competency and performance to co-align its integrative strategies with environmental changes. This study extends the discussion from a static perspective to a dynamic perspective.

In a dynamic supply chain, based on the contingency theory (Cao et al., 2015), a supply chain's integration strategy should align with demand uncertainty to deliver optimal performance. We first assume an infinite certain demand scenario, in which future demand features are easily predictable. Thus, original equipment manufacturers (OEMs) tend to operate their supply chains using a lean approach with steady orders to achieve higher operational effectiveness and lower inventories (Agarwal, Shankar, & Tiwari, 2006). Integrative collaborations between OEMs and suppliers can enhance production quality and delivery performance (Jonsson et al., 2011). In the meantime, information on demand features is generated by consumers, and flows from the downstream customer upwards. Although researchers have claimed that OEM's integration with downstream customers would improve the ability of OEMs to gather accurate and in-time demand information, which supports OEM demand response efficiency (Devaraj et al., 2007), the integration cost including capital cost and managerial effort input with downstream customers, might exceed the extracted value of demand information. This is an intuitive inference that there is no need to adjust demand prediction frequently when OEMs operate with low demand uncertainty. Thus, given a certain level of integration investment, the marginal benefit of integration with suppliers tends to be higher than integration with customers, because the supply chain manager realized more integrative value from suppliers. In other words, the lower demand uncertainty might moderate on the supplier side more than the customer side.

When demand features become infinitely uncertain, the prediction of demand changing direction and intensity gain more operational priority in OEMs' management (Sabath, 1995). This is especially true for long production cycle supply chains, as in the automotive industry. Lyons, Coleman, Kehoe, and Coronado (2004) indicate that with more than five years from initial design to vehicle production, failure to monitor and predict market demand change will lead to lacklustre sales and loss of market share. In the absence of obtaining frequent and up-to-date demand information from downstream customers, OEMs might fail to re-allocate and re-configure their supply chain resources. Such failure may further lead to inaccurate exploitation of scarce resources which is the foundation of retaining supply chains' core competency (Hung et al., 2009). By contrast, without accurate demand change recognition, higher production effectiveness achieved via integrating suppliers may merely promise higher inventory levels with lacklustre sales. The integrative collaborations between OEMs and suppliers provide dual constraints for either OEMs in finding new suppliers and for suppliers in exploring new supply chains (Cao & Zhang, 2011). Therefore, the marginal realized value from customer integration might exceed it from the suppliers' side. Given a certain level of integration efforts, OEMs that are experiencing high demand uncertainty must have preferences on integrating customers. Intuitively, a high level of demand uncertainty may moderate more on the customer side than the supplier side.

With the final purpose of achieving optimal operational performance (OP), the built-in dynamic capability enables OEMs to re-evaluate and re-configure supply chain resources once demand uncertainty upgrades. As a part of supply chain intangible resources, the realized value on different integration dimensions changes along with resource re-allocation, which eventually leads to the change of SCI strategies. Thus, this dynamic co-alignment process suggests that supply chain operational performance will be optimal if an integration strategy is accompanied by changing demand uncertainty. Existing empirical studies' claim of a monotonous moderating effect from demand uncertainty on the relationship between SCI and OP is incomplete (He & Zhao, 2012; Jonsson et al., 2011). Based on the answer to how DU moderates such relationships should depend on the level of DU rather than on whether DU exists. Thus, we propose the following hypotheses:

Hypothesis 1. Demand uncertainty moderates the positive relationship between external integration (supplier integration and customer integration) and operational performance.

Hypothesis 2. There is a trade-off between demand uncertainty's moderating effects on the relationship between supplier integration and operational performance and on the relationship between customer integration and operational performance.

Internal integration should be distinguished from external integrations, given that production performance and delivery performance are more sensitive to external integrations (Koufteros, Vonderembse, & Jayaram, 2005). In addition, Zhao, Huo, Selen, and Yeung (2011) indicated that internal integration acts as a bridge between external integrations, and its strengths definitely bring greater effectiveness to external integrations. In a context with uncertainty, managerial efforts towards external integrations have been hypothesized to vary as the level of uncertainty changes. Thus, the adjustments to integration configuration strategy do not necessarily lead to or require from a change of bridging link. Although integrative internal integrations should always contribute to overall performance, its contribution might be lost in external integrations' effect.

Hypothesis 3. Demand uncertainty does not moderate the positive relationship between internal integration and operational performance.

3. Research methodology

To test the proposed hypothesis, we identified the automotive OEMs in China as research universe, because China is considered to be the largest automotive market and the largest automotive producing country in the world (Bennett & Klug, 2012; Lockström, Schadel, Harrison, Moser, & Malhotra, 2010). China has undergone a profound transformation over the last two decades (Cai, Jun, & Yang, 2010; Flynn et al., 2010). The scope and scale, in terms of product categories and market uncertainties (Li, Ning, Zeng, & Xin, 2014) in China, have made it suitable for the purpose of this study. Furthermore, the whole automotive industry in China is maturing rapidly and has had inextricable connections to all major global automotive supply chains (Lockström et al., 2010), which will lead to more general research implications for global supply chain management.

3.1. Questionnaire design and measures

We used a questionnaire as one of the main empirical instruments for data gathering from a sample group of selected Chinese automotive OEMs across the country. The questionnaire was developed in three stages. During the first stage, the measurements of the three key constructs, SCI, OP and DU were developed based on what has been established from the literature. We referenced SCI and OP measures against Flynn et al. (2010) and DU measures against He and Zhao (2012). In the second stage, we held several online video meetings with relevant directors and managers to validate the questionnaire and the measurement indicators. Finally, a pre-test process was carried out in 20 selected companies to further assure the validity of the questionnaire. The items were all measured using a seven-point Likert scale. The completed scales are listed in Table 1.

Table 1. Reliability and validity analysis of theoretical constructs

	Items	Loading	Score	Cronbach alpha	KMO
SI	SI1—quick ordering system with our major supplier	0.76	0.19	0.85	0.80
	SI2—strategic partnership with our major supplier	0.68	0.13		
	SI3—our major supplier shares their production schedule with us	0.57	0.13		
	SI4—our major supplier shares their production capacity with us	0.81	0.14		
	SI5—our major supplier shares available inventory with us	0.83	0.17		
	SI6—we share our demand forecasts with our major supplier	0.62	0.16		
	SI7—we share our inventory levels with our major supplier	0.70	0.16		
	SI8—we help our major supplier to improve process to better meet our needs	0.83	0.16		
CI	CI1—the level of computerization for our major customer's ordering	0.77	0.18	0.84	0.77
	CI2—the level of sharing of market information from our major customer	0.61	0.18		
	CI3—the establishment of quick ordering systems with our major customer	0.83	0.18		
	CI4—the frequency of period contacts with our major customer	0.75	0.18		
	CI5—our major customer share point of sales information with us	0.66	0.16		
	CI6—our major customer shares demand forecast with us	0.77	0.19		
	CI7—we share our available inventory with our major customer	0.79	0.19		
II	II1—data integration among internal functions	0.64	0.19	0.90	0.88
	II2—enterprise application integration among internal functions	0.75	0.20		
	II3—integrative inventory management	0.69	0.18		
	II5—real-time searching of logistic-related operating data	0.80	0.26		
	II6—the use of cross-functional teams in process improvement	0.87	0.22		
	II7—the use of cross-functional teams in new product development	0.71	0.22		
OP	OP1—we can quickly modify products to meet our customer's requirements	0.76	0.25	0.84	0.81
	OP2—we can quickly introduce new products into the markets	0.79	0.25		
	OP3—we can quickly respond to changes in market demand	0.74	0.24		
	OP4—we have an outstanding on-time delivery record to our major customer	0.84	0.25		
	OP5—the lead time for fulfilling customers' orders is short	0.87	0.24		
DU	DU1—order change frequency	0.74	0.35	0.79	0.80
	DU2—order volume unpredictable	0.78	0.30		
	DU3—order preference change	0.77	0.30		
	DU4—product life cycle change	0.88	0.31		

3.2. Sampling and data collection

In order to decide an appropriate representative sample group of OEMs, we contacted the China Automotive Association to obtain registered manufacturers list which involves 237 OEMs. We randomly select OEMs by largely an impartial sampling process as suggested by Seber (1982). The selection process aims to include a minimum number of OEMs based on their features which can represents the feature distribution of the total population. Such features include company size, annual revenue, number of employees and regions. As a result, 65 OEMs have been selected and subsequently contacted via phone calls. A total of 700 questionnaires were sent with 477 returned, achieving a return rate of 68.1%. Out of the 477 returned questionnaire, 120 were invalid, yielding a total of 357 valid responses, which represented a valid response rate of 51%. We evaluated the non-response bias by comparing the early and late responses using t-test (Gimenez et al., 2012). No significant non-response bias was found. The respondents are selected from experienced managers from junior to chief levels. More than half of the respondents have been in their position for more than three years, which is a positive attribute to the credibility of the responses.

To further mitigate potential common method bias (CMB), Harman's *one-factor test* (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) is performed on all 30 items. The result shows that no single common factor is apparent. To further assess the CMB, we applied confirmatory factor analysis (CFA) (Huo, 2012) with the null model being that all measurement items were assigned to a single construct in order to check the CMB. The result comes with: $\chi^2 = 3,997.532$, $df = 405$, $\chi^2/df = 9.87$, GFI = 0.652, AGFI = 0.48, CFI = 0.4, RMSEA = 0.37, showing that the null model does not fit to the data at all. Thus, CMB is not an issue for the data.

3.3. Reliability and validity

Then, we move on to test reliability of each construct, as shown in Table 1, the Cronbach's alpha measure has been performed on the data sample to test whether significant difference of reliability between the trial data sample and the final data sample exists. The estimated Cronbach's alphas are 0.85 for SI, 0.84 for CI, 0.90 for II, 0.84 for OP and 0.79 for DU, respectively, and the Cronbach's alpha for all constructs is 0.861, indicating that all constructs met internal consistency requirement. As to perform exploratory factor analysis, the KMO measure ranges from 0.771 to 0.882, and the identity matrix hypothesis has also been rejected with chi-square ($df = 464$) = 399.044 ($p < 0.001$), which satisfies the requirement of suitability.

A two-step approach (first dimension reduction and regression analysis) suggested by Yusuf, Gunasekaran, Adeleye, and Sivayoganathan (2004) is applied to analyse the final data sample. CFA is used to reduce the 30 items to 5 constructs: OP, SI, CI, II and DU. The factor scores are used to determine an item's relative standing on its corresponding construct (Brown, 2015; Yusuf et al., 2004). This study used obtained factor scores of the 30 items to generate data columns of the 5 constructs (Flynn et al., 2010; Sezen, 2008; Won Lee, Kwon, & Severance, 2007), on which all remaining analysis will be based.

4. Results and discussion

4.1. Results

In line with contingency theory, the uncertain level of demand forces supply chain managerial behaviours to co-align integration strategies to cope with the environmental changes, and the various integration strategies lead to different operational performance. In addition, demand uncertainty is generated exogenously from supply chains; thus, there is no theoretical implication on testing a direct relationship between operational performance and demand uncertainty. Existing studies subjectively divided uncertainty into high and low intervals (Huang, Yen, & Liu, 2014; Wong et al., 2011), Flynn, Koufteros, and Lu (2016) claimed that different levels and dimensions of uncertainty moderate integration strategies in different ways. Thus, there is a call to measure uncertainty with its full spectrum and to investigate its dynamic moderating effects (Flynn et al., 2016). To perform a dynamic investigation on the moderating effects of demand uncertainty, Hansen (2000) suggests the use of threshold regression analysis (TRA). The choice of threshold regression method is based on the fact that threshold regression is capable of identifying the underlying thresholds that partition the data into groups and to achieve their corresponding relationships through regressions. According to Hansen (1999), TRA can avoid unpredictable errors caused by subjective division, and it can endogenously divide intervals based on the data characteristics, then estimate the relationships within each interval and eventually form the distinct shape of a relationship.

In Model 1–3 as shown in Table 2, DU acts as the threshold variable; a statistically significant threshold value of DU will lead to different regression coefficients of SCI on OP, which indicates the existence of DU's moderating effect on the SCI–OP relationships. Although we failed to observe the moderating effect of DU on II, two thresholds within the relationships between SI (threshold 1: $DU = 3.88$; threshold 2: $DU = 6.28$), CI (threshold 1: $DU = 4.23$; threshold 2: $DU = 5.81$) and OP have been found. The estimated threshold values of SI divided the data-set into three regimes in terms of high uncertain demand ($DU \leq 3.88$), middle uncertain demand ($3.88 < DU \leq 6.28$) and low uncertain demand ($DU > 6.28$). As shown in Figure 1, the results suggest that SI is negatively related to OP in the first

Table 2. Regression results of the SCI–OP relationships under DU

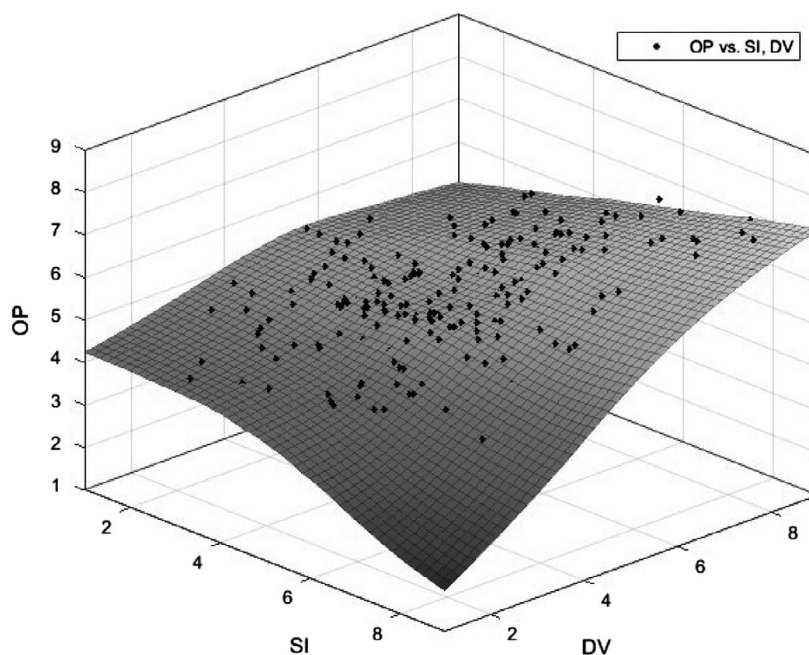
Regressor	Model 1	Model 2	Model 3
No. of thresholds	0	2	2
Thresholds value		[3.88, 6.28]	[4.23, 5.81]
II (DU)	0.17**		
SI (DU < 3.88)		–0.19**	
SI (3.88 < DU < 6.28)		0.06*	
SI (DU > 6.28)		0.23**	
CI (DU < 4.23)			0.24**
CI (4.23 < DU < 5.81)			0.08*
CI (DU > 5.81)			–0.11**
Adjusted- R^2	0.51		

Note: Bootstrap = 2,000.

* p -value < 0.05.

** p -value < 0.01.

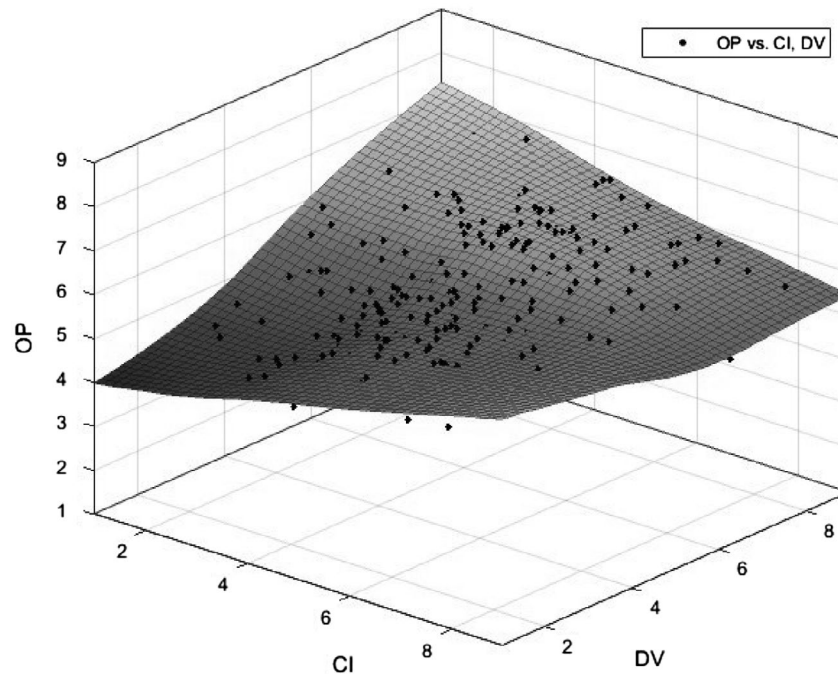
Figure 1. 3D plot of the relationship from SI to OP with DU, generated by locally weighted scatterplot smoothing (LOWESS).



regime, which could be an unexpected finding for some researchers who believe it contradicts the “common sense” on the positive relationship in many integration and performance studies. On the other hand, the estimated slopes become positive in the second and third regimes, and the magnitude of the slopes rise from 0.06 to 0.23 when it shifts from the second to the third regime. The estimated SI–OP relationship coefficients rise from negative to positive as demand becomes less uncertain.

The obtained two thresholds of DU on the CI–OP relationship also divided the data-set into three regimes. Such a scenario of three regime division is comparable to what has been obtained in analysing SI–OP relationships. The three regimes were divided based on a pair of estimated threshold values, however, the estimated threshold values (4.23, 5.81) in the CI–OP model differ from those in the SI–OP model (3.88, 6.28), and the former shows more cohesion than the latter. As shown in Table 2 and Figure 2, all the regime-dependent coefficients of CI are significant and plausibly signed. The

Figure 2. 3D plot of the relationship from CI to OP with DU.



coefficient in the ‘high uncertain demand’ regime is 0.24, which indicates that CI is helpful for OP growth when demand uncertainty tends to be high. If CI increases 1 unit, OP will increase 0.24 units, *ceteris paribus*. In the ‘middle uncertain demand’ regime, CI still has a positive impact but with lower magnitude (0.08) on OP. After the second threshold, it was unexpected that CI became harmful for OP growth (−0.11). Note that the absolute size of CI’s coefficient suggested that it may worsen OP’s growth if CI gets too high. These findings appear to squarely support H_1 , H_2 and H_3 .

Our findings reveal certain theoretical implications of DCT. Uncertainty is a critical factor in triggering supply chains’ built-in dynamic capability, which justifies the behaviour of re-evaluating and re-configuring SCI as intangible resources to an appropriate mode that is aligned with the changes of environment (Makadok, 2001). In keeping with DCT, if uncertainty turns higher, supply chain OEMs should realize more resource-based value from enhancing CI. This premium value is the increasing importance of obtaining more accurate market information for prediction. The empirical results of this study demonstrate that, when DU turns from low to high, the moderating effect of DU on the CI–OP relationship turns from negative to positive with a growing magnitude. Conversely, when DU changes from high to low, DU performs similar moderating effect on the SI–OP relationship. These empirical results analytically explained how OEMs conducted their *ex post* adaptation by facing different levels of uncertainty. The existence of such adaptation theoretically proved the implemented dynamic capability in the supply chain management mechanism. Previous studies that have investigated the moderating effect of uncertainty are *ex post* analyses (Bernstein & Federgruen, 2005; He & Zhao, 2012; Wong et al., 2011), that examined the SCI–OP relationship changes under a certain level of uncertainty. This study allowed us to observe uncertainty’s moderating effects with its full spectrum and OEMs’ strategic adaptations subject to the level of uncertainty.

This study also demonstrates that DU does not moderate the II–OP relationship. In contrast to several previous studies that have concluded straightforward environmental moderating effects on the SCI–OP relationship, our findings complement previous studies that have advocated non-significant moderating effect on II. Thus, our study also contributes to the contingency-related research in supply chain management and operations management domains.

4.2. Managerial implications

Based on contingency theory, a supply chain's optimal operational performance is achieved when there is a good fit between integration strategy and the external environment (Cao et al., 2015). DCT further explains how supply chain managers adjust integration strategy to cope to a changing environment (Makadok, 2001). Our findings suggest that environmental uncertainty only moderates on the contribution of external integration to performance. In the meantime, when uncertainty is monotonous, there is a trade-off between its moderating effects on the supplier side and customer side. Thus, managerial discretion with respect to addressing environmental uncertainty is frequently reflected in supply chain managers' behaviours upon finding an optimal leveraging point within external integrations.

Several studies have stated that extensive integration may result in the loss of strategic competency and may compromise a supply chain's ability to meet its operational goals when environmental uncertainty is turbulent (Terjesen, Patel, & Sanders, 2012). These studies also suggest loosening close and integrated supply chain collaborations by allowing supply chain participants to switch with flexibility, which allows for rapid response to dynamic market requirements. Conversely, our study indicates that the adjustment of integration strategy depends on the change of realized value from integrations, and the value changes are associated with the change of environmental conditions. Thus, given a certain level of environmental uncertainty, to simply enhance or weaken SCI is not an appropriate choice. Supply chain managers should adopt a trade-off strategy that emphasizes resource value over integrations to achieve optimal operational performance by sustaining competitive advantage in the long term.

5. Conclusions

We critically reviewed the recent literature in the subject area and identified several inconsistencies and research gaps. The goal of this study was to discuss and investigate the moderating effect of demand uncertainty on SCI-OP relationships in a dynamic context. The TRA was used to validate a model of SCI-OP relationships that allows DU's moderating effects in a full spectrum. To the best of our knowledge, this report presents the first description of TRA as the primary analysis method to analyse operation management issues. By doing so, our findings evolve previous contingency-response relationship studies that have advocated a dynamic perspective, and further, they help to clarify the moderating effects with full spectrum of contingencies. A trade-off moderating effect on external integrations is likely to exist in the context of demand uncertainty. In practice, supply chains may need to find a balance between the supplier side and customer side if they are well-integrated.

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